# SPC/NSSL SPRING PROGRAM 2004

**http://www.spc.noaa.gov/exper/Spring_2004**
**SPC/NSSL Science Support Area**
**19 April - 4 June 2004**

# Program Overview and Operations Plan

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# I. Historical Perspective

Co-location of the Storm Prediction Center (SPC) with the National Severe Storms Laboratory (NSSL) and other agencies in the Norman, OK Weather Center has facilitated considerable interaction and collaboration on a variety of experimental forecast and other operationally relevant research programs. A wide cross section of local and visiting forecasters and researchers has participated in a number of programs over the past six years. These include forecasting support for field programs such as IHOP, establishing the SPC winter weather mesoscale discussion product, evaluating operational and experimental NWP models for application in convective forecasting, including Short Range Ensemble Forecast (SREF) systems, and integrating new observational data, objectives analyses and display tools into forecast operations. A key goal of these programs is to improve forecasts of meteorological phenomena by speeding up the transfer of new technology and research ideas into forecast operations at the SPC, and sharing new techniques, skills, and results of applied research more freely. Typical issues addressed in these activities include, but are not limited to: data overload concerns in operations, testing and evaluation of new analysis or predictive (NWP) models, better understanding of operational forecast problems, development and evaluation of diagnostic conceptual models, and new product development and display strategies.

During the Spring of 2000, 2001, and 2003 these collaborative programs focused on critical SPC operational products including the predictability of severe and non-severe thunderstorms and potential impact on operational convective outlook skill and convective watch lead time. During the Spring of 2002, the program focused on providing forecasting support for the IHOP field project, primarily addressing afternoon convective initiation and nocturnal MCS development.

Details about earlier Spring Programs are available at:
www.spc.noaa.gov/exper/Spring_2000
www.spc.noaa.gov/exper/Spring_2001
www.spc.noaa.gov/exper/Spring_2002
www.spc.noaa.gov/exper/Spring_2003

This document will provide an overview of logistical, personnel, planning and verification issues involved in the Spring Program for 2004.

# II. Program Motivation, Goals and Objectives

The prediction of convective weather is important from both meteorological and public service/societal impact perspectives. Since a primary mission of the National Weather Service is the protection of life and property from hazardous weather phenomena, applied research aimed at improving the forecasting of severe thunderstorms and tornadoes is a critical responsibility at the Storm Prediction Center (SPC) and the National Severe Storms Laboratory (NSSL).

The SPC is responsible for the prediction of severe convective weather over the contiguous United States on time scales ranging from several hours to three days. To meet these responsibilities, the SPC issues Convective Outlooks for the Day 1, Day 2 and Day 3 periods to highlight regions with enhanced potential for severe thunderstorms (defined as thunderstorms producing hail $\geq$ 3/4 inch in diameter, wind gusts $\geq$ 50 kt or thunderstorm induced wind damage, or tornadoes). These outlooks are issued in both categorical (slight, moderate, or high risk) and probabilistic formats, and are issued with increasing frequency as the severe weather time frame draws nearer. In addition to the scheduled Outlooks, Severe Thunderstorm and Tornado Watches are issued on an as-needed basis to provide a higher level of alert over smaller regions in time and space when atmospheric conditions are favorable for severe thunderstorms and/or tornadoes to develop. The SPC also issues Mesoscale Discussion Products that emphasize hazardous weather on the mesoscale and often serve to fill the gap between the larger scale Outlooks and near-term Watches. These specialized forecast products depend on the ability of SPC forecasters to assess the current state and evolution of the environment over varied time frames, synthesizing a wide variety of observational and numerical model data sources. In general, observational data play a larger role in the shorter time frames for diagnostic purposes, however, the development of more accurate and higher resolution mesoscale models in recent years has allowed model information to play an increasing role in the short-term prediction of convection as well.

An effective NWS severe weather forecast and warning program is dependent on providing the public with sufficient advance notice of impending hazardous weather. Human response studies have shown that when a warning is issued, people are more likely to seek shelter if they have been made aware of the severe weather threat prior to the issuance of the warning. However, if they have not been "pre-conditioned" to the threat prior to hearing a warning, their first response is often to seek confirmation of the threat, rather than to seek shelter. This can result in the loss of precious time when life and property are at immediate risk. Thus, there is a substantial need for SPC to issue severe weather watches prior to the issuance of warnings by local WFOs, in order to allow WFO staffs, emergency managers, etc. sufficient time to implement contingency plans prior to the onset of severe weather. Accordingly, over the last year SPC has embarked on a program to increase the lead time of convective watches.

However, this places additional requirements on SPC forecasters to determine in advance the characteristics of potentially severe thunderstorm activity. In recent years, it has become especially evident that the type of severe weather that occurs (tornadoes, hail, or damaging winds) is often closely related to the convective mode (or morphology) that storms exhibit, such as forming in discrete cells, squall lines (or quasi-linear convective systems (QLCS)), and multicellular convective systems. In addition, some severe storms develop as dynamically unique classes of thunderstorms such as supercells and bow echoes, which are believed to produce a disproportionate number of tornado and widespread straight-line wind damage events, respectively. Thus, accurate severe weather forecasts are dependent on forecasters being able to properly predict not only where and when severe thunderstorms will develop and how they will evolve over the next 4 – 7 hours, but also the convective mode(s) that are most likely to occur.

Given our primary mission of mesoscale forecast responsibility, it is not only prudent but necessary to place a strong emphasis on diagnostic analysis using real-time observational data for short-term thunderstorm prediction. However, owing to insufficient sampling of the mesoscale environment (especially when the distribution of water vapor is considered) coupled with limited scientific knowledge of important mesoscale and storm-scale processes, considerable uncertainty still exists in the short-term prediction of convection. It is possible that this uncertainty can be reduced through the use of new numerical models and new configurations of existing models. In particular, near-stormscale configurations of the WRF-Mass Core and WRF-NMM look promising. Consequently, it is important to see how forecasts of convection from the WRF models compare to operational mesoscale model forecasts, including output from the EMC SREF system, and to determine if information from the new WRF model can help us more confidently predict not only when and where convection will develop, but also provide details about convective intensity, evolution and mode that are typically not evident from current operational modeling systems.

Through partnerships with the National Centers for Environmental Prediction Environmental Modeling Center (NCEP-EMC), the National Center for Atmospheric Research (NCAR), and the University of Oklahoma Center for Analysis and Prediction of Storms (OU-CAPS), we will examine several different versions of the WRF model incorporating both the NCAR dynamic core and the EMC-NMM core. This will allow us to explore the impact of different model numerics, physics packages, and grid resolution on model predictions, and to determine if the value-to-cost ratio is high enough to justify the enormous computer and communications resources required to produce model guidance at 4 km grid spacing in an operational setting. A key component of the program is the participation of operational SPC forecasters, whose insights and experience provide a real-world severe weather forecasting perspective when assessing the usefulness of high resolution WRF models, and the resultant likelihood that output from these models will result in improved severe weather forecasts

The overall goal of the Spring Program is to facilitate collaboration and interaction between SPC forecasters, NSSL scientists, and other researchers and forecasters to advance operationally relevant research and improve severe weather forecasts. **During Spring Program 2004, the primary objectives are to determine: 1) if there is new and useful information in the very high resolution WRF runs from a forecaster perspective, and 2) whether severe weather forecasts can be improved when forecasters have access to new near-stormscale models using explicit precipitation physics, compared to mesoscale models with parameterized convection.** A secondary objective is to further explore the application of SREF guidance as a complement to deterministic model output, and to assess the use of statistical products from the SREF system in quantifying uncertainty in severe weather forecasts.

## III. Program Focus Areas

Spring Program 2004 will have seven (7) research focus areas:

1. Compare the ability of mesoscale models with parameterized convection and near-stormscale models with explicit precipitation physics to predict convective initiation, evolution, and mode in potential severe weather episodes, and determine if there is value added by the 4 km WRF runs.

2. Examine several different model output products used to indicate development of deep convection (such as accumulated precipitation over three- and one-hour periods, instantaneous precipitation rate, and equivalent reflectivity) and compare their usefulness to provide guidance about convective initiation, intensity, evolution, and mode.

3. Examine forecasts from the WRF-NMM and WRF-Mass Core to identify performance characteristics of each model version as they relate to convective development during potential severe weather episodes.

4. Explore the impact of using a state-of-the-art data assimilation system (ADAS) coupled with Level II Radar Data in a 4 km WRF-Mass Core model by comparing the forecasts of convective development to those from a similar WRF model without direct data assimilation/radar data.

5. Determine if operational severe weather forecasters find utility and value in models producing more detailed convective structures compared to those producing more smoothed, less detailed convective structures.

6. Determine if short-term severe weather forecasts are improved when forecasters have access to output from experimental near-stormscale models.

7. Explore applications of SREF model guidance to complement use of deterministic model output in severe weather forecasting.

## IV. Spring Program Web Site

A full description of all program objectives, types of model output, forecast products, evaluation and verification forms, daily weather summary, and other related links are available at the Spring Program web site:

**http://www.spc.noaa.gov/exper/Spring_2004**

This web site will be fully operational by 19 April 2004. The site is intended to support real time activities as well as additional research and reference after the conclusion of the program.

## V. Dates and Participants

Spring Program 2004 will run Monday-Friday 8 am – 4 pm from 19 April through 4 June 2004. Full time participants will work shifts of one week, with part-time visiting scientists and forecasters participating on a 2-3 day basis (schedule permitting). Program operations will be conducted in the Science Support Area (SSA) located adjacent to the SPC Operations area. The full time forecast team will consist of four forecasters and/or scientists who will complete daily experimental forecasts and participate in evaluation and verification activities. Staffing typically will include one SPC forecaster, one NSSL scientist and two visiting scientists and forecasters from NCEP/EMC and other NWS facilities, Forecast Systems Laboratory, CIMMS/University of Oklahoma, Iowa State University, University of Arizona, University of Wisconsin-Madison, University of Wisconsin-Milwaukee, Penn State University, University of Colorado, University of Utah, University of Missouri-Columbia, University at Albany-SUNY, Naval Postgraduate School, NCAR, NASA-Marshall Space Flight Center, and Meteorological Service of Canada. ***Visiting participants are invited to present a seminar related to Spring Program goals; interested visitors should contact Steven Weiss (steven.j.weiss@noaa.gov).*** A brief orientation/training session will be provided to all participants on the morning of their first scheduled shift. **A schedule of participants is provided in Attachment A.**

## VI. Daily Operations Schedule

SPC, NSSL, and visiting staff will create forecast products, conduct evaluation activities and participate in a daily map discussion in the Science Support Area from 8 am - 4 pm on Monday-Friday. Occasional seminars by visiting scientists will be scheduled to occur at 4 pm in the NSSL Conference Room upon completion of daily program activities.

Participants are expected to perform evaluation activities in a collaborative manner, such that results reflect a consensus decision. Participants may eat lunch while conducting program activities or at their discretion any time during the day. Here is an outline of the daily schedule for activities during the Spring Program:

**<u>Monday-Friday</u>:**

| | | | | | |
|---|---|---|---|---|---|
| 7:30 a.m. | - | 8:00 a.m. | - | Orientation (Monday only) |
| 8:00 a.m. | - | 9::00 a.m. | - | Complete online forms for determination of previous day convective mode and subjective verification of preliminary and final severe weather forecasts |
| | | | - | Select today's forecast and evaluation domain based on 13z SPC Outlook |
| 9:00 a.m. | - | 11:00 a.m. | - | Using traditional analy6sis techniques and assessment of deterministic and SFEF models, prepare and issue preliminary severe weather forecast (NAWIPS graphic and online text discussion) valid 18-00z today. |
| 11:00 a.m. | - | 11:30 a.m. | - | Complete online forms for subjective evaluation of forecaster perceived confidence in and utility of operational mesoscale model guidance |
| 11:30 a.m. | - | 12:30 p.m. | - | Using high resolution WRF model output, prepare and issue updated (final) severe weather forecast (NAWIPS graphic and online text discussion) valid 18-00z today. |
| 12:30 p.m. | - | 1:00 p.m. | - | Complete online forms for subjective evaluation of forecaster perceived confidence in and utility of high resolution WRF model guidance. |
| 1:00 p.m. | - | 1:30 p.m. | - | SPC/NSSL Map Discussion |
| 1:30 p.m. | - | 4:00 p.m. | - | Complete online forms for subjective verification of mesoscale and high resolution model forecasts for previous day. |
| | | | - | Summarize activities, archive data, and wrap-up |

## VII. Forecast Products

An experimental forecast component is a key part of the program, and it consists of formulating two short-term probabilistic severe weather forecasts valid for the current day from 18-00z. *(If deep convection is unlikely to develop before 00z and primary development is delayed until near or after 00z, the forecast period can be changed to 21-03z or 00-06z if appropriate. It is anticipated that this change will occur only on a small number of days during the program.)* The intent of the forecast component is to examine the ability of experienced severe weather forecasters to issue detailed severe weather forecasts for the afternoon and early evening with emphasis on the timing and location of initial convective initiation, subsequent convective evolution, and aspects of convective mode. A key goal will be to determine the value-added impact of experimental near-cloud resolving WRF model output, which will be used by forecasters to adjust earlier forecasts based on operational mesoscale model guidance from the Eta, RUC, and SREF systems.

Two severe weather forecasts will be issued. The first will be a preliminary forecast issued by 11 am CDT based on mesoscale model output. The second will be a final forecast issued by 12:30 pm CDT, and will incorporate additional output from three 00z 4 km WRF model runs: 1) Mass Core from NCAR initialized using 40 km Eta background fields, 2) Mass Core from OU/CAPS initialized using ADAS (ARPS Data Assimilation System) and Level II radar data, and the WRF-NMM from EMC. Output from the three WRF runs will be used to modify, if needed, the forecast probabilities issued in the preliminary forecast. In this way, we can compare the two experimental forecasts and assess the impact of using near cloud-resolving WRF model output in the forecast process to determine if application of higher resolution models contributes to the issuance of more detailed and accurate severe weather forecasts.

Each severe weather forecast will consist of a graphical product, assignment of probability of several basic convective modes (**See Attachment F for detailed information on convective mode categories**), and a short written discussion explaining the rationale of the forecast, emphasizing the role of the model guidance in the decision-making process and focusing on key uncertainties in the forecast. The severe weather forecasts will be similar to the SPC operational probabilistic severe outlooks, and will include the probability of all severe weather types combined (large hail, convective wind gusts > 50 kt and/or thunderstorm wind damage, and tornadoes), and areas where the probability of significant severe weather (tornadoes $\geq$ F2, hail diameter $\geq$ 2 inches, or winds gusts $\geq$ 65 kt) is 10% or greater.

In order to limit the size of the geographic area the forecasts are valid for, the experimental products will roughly focus on severe risk area(s) delineated in the 13Z SPC Day 1 Outlook, covering regions of 8 deg latitude by 14 deg longitude (480 nm by 840 nm). If more than one severe risk area is included in the 13Z Day 1 outlook, the forecast team will choose one of the risk areas to concentrate on the area with the highest or most significant severe threat during the afternoon or early evening hours. Since we are most interested in timing/location of the ***initiation*** of convection and severe storms, rather than the ***continuation*** of existing convection and severe storms, these considerations will affect the choice of outlook areas. Also, areas of potential nocturnal convection developing after sunset should be avoided as these events will most likely take place outside of our forecast time period.

The experimental forecast severe weather probability contours will be chosen from the same contour values as used in SPC operational severe outlooks: 5, 15, 25, 35, and 45%. These represent the coverage of expected severe weather, and can also represent a measure of forecast uncertainty. Any areas where the probability for significant severe events is 10% or greater will be denoted by the standard hatched area. The probability forecasts will be verified using an 80 km grid, so they are equivalent to the probability of a severe weather event occurring within 25 miles of a point. The severe weather forecasts will be verified using both subjective and objective methods, based on severe storm reports collected by SPC from local storm report (LSR) products issued by NWS WFOs across the country.

Experimental severe weather forecasts will be issued twice daily and are valid for the same time periods:

| **Outlook** | **Issue Time** | **Valid Period** |
|---|---|---|
| Preliminary | 1600z (11 am CDT) | 1800-0000z* |
| Final | 1730z (12:30 pm CDT) | 1800-0000z* |

* *If deep convection is unlikely to develop before 00z and primary development is delayed until near or after 00z, the forecast period can be changed to 21-03z or 00-06z when appropriate.*

It is expected that the forecasters will need to make their primary decisions no later than 45 minutes prior to the issuance deadline (i.e. by 1515Z and 1615Z in order to complete forecast graphics, assignment of mode probability values, and text discussion by issue time), thus real-time observational data is expected to play a secondary role in the forecast process. This is not intended to diminish the importance of observational data in actual forecast operations, but to see if the model output contains useful and unique information that allows forecasters to develop an early mental picture of how convection will unfold, and to assign a level of confidence to the scenario they come up with.

After each forecast package is issued, the forecast team will complete multiple choice evaluation forms that will be used to document the usefulness of various sources of model information and displays in the forecast decision-making process. The forms will also contain space to provide comments that elaborate on the forecast decision-making process, focusing on the utility of mesoscale and high resolution model guidance in formulating the severe weather forecast. In order to complete the form in a timely manner, part of the forecast team should begin completing it while the forecast discussion is being written.

**Instructions for creation of the experimental forecast product is in Attachment B; the real-time model evaluation instructions are in Attachment C.**

## VIII. Evaluation and Verification Activities

Every morning, evaluation of the preliminary and final experimental severe weather forecasts valid for the previous day will be conducted early in shift. (On Monday morning, the forecasts valid for Friday will be evaluated). In addition, radar reflectivity data will be used to identify the convective mode(s) that occurred during the forecast period, and any relationship between mode and the severe reports.

The evaluation of these forecasts will be over the domain selected the previous day, and will utilize plots of the forecast probabilities overlaid on the severe report plots to assess the accuracy and usefulness of the forecasts. It is important to make sure the team members assess the two forecasts (Preliminary and Final) using the following criteria: 1) how well they delineated regions where severe reports occurred (spatial accuracy), 2) how well they exhibited a sense of reliability (more reports occurred in regions with higher probabilities), and 3) comparison of the two forecasts in a relative sense, e.g., did the update provide better, worse, or the same level of accuracy? The verification will include numerical ratings from 0-10 and an opportunity for a brief written discussion explaining the rating decision. Objective statistical verification of the forecasts will also be conducted, as we view these two methods as being complementary. **More information about the experimental forecast verification forms is found in Attachment D.**

Every afternoon, model forecasts of precipitation areas, precipitation rate, and/or reflectivity valid for the previous afternoon and evening will be verified. The subjective assessment will include the following 00z models: NCAR 4 km WRF, CAPS 4 km WRF, and EMC 4 km WRF-NMM; and the following 12z models: CAPS 4 km WRF, EMC 8 km WRF-NMM, 12 km Eta, and 20 km RUC. (*To display the WRF models and full resolution output from the WRF and Eta models, a special Spring Program 2004 NMAP2 version is required. In an xterm window, type* ***sp2004*** *to bring up the special NMAP2 window*.) The verification domain will be identical to the forecast domain selected the previous day, which is adjusted daily to focus on the area having the greatest severe potential based on the 13z SPC Day 1 severe outlook. Verification will be made by comparing model predicted accumulated precipitation, instantaneous vertical velocity, and/or reflectivity forecasts with mosaic images of radar base reflectivity. The intent ***is not*** to perform a QPF verification, because storm severity is not necessarily correlated with precipitation amounts. What we are most interested in is the ability of the model precipitation and reflectivity forecasts to provide useful guidance to severe weather forecasters interested in predicting the "where", the "when", and the spatial pattern of thunderstorm development, including information about convective mode. Our working concept is this: if we have a good idea how the timing, location, and evolution of afternoon convection will unfold, our ability to issue high quality severe weather watches will increase in some situations. In addition, we will examine more closely comparisons between the mesoscale models with parameterized convection and near-stormscale models with explicit precipitation physics. Our main goal here is twofold: 1) to assess the impact of substantially increased resolution and explicit physics in the 4 km WRF versions, and 2) to determine if instantaneous precipitations rate and/or reflectivity products can assist forecasters in identifying more detailed structures and aspects of convective mode compared to accumulated precipitation products over 1- and 3-hour periods. It has been shown that subjective verification of mesoscale model precipitation fields provides important information about human perception of model performance, since traditional measures such as Equitable Threat Score can provide misleading information when small scale features are considered. **See Attachment E for more information about the model forecast verification forms.**

## IX. Daily Map Discussion

A daily map discussion is typically held from 1:00-1:30 pm in the SSA to bring together SPC forecasters and NSSL scientists for an informal discussion of interesting and/or unusual weather around the country, focusing primarily on severe storms during the spring season. During the Spring Program time period, we will focus discussion on aspects of the Spring Program activities, including the subjective evaluation of yesterday's experimental forecasts, and the formulation and rationale of the two morning forecasts, including perceptions of the usefulness of mesoscale and near-stormscale models that were used in the forecast preparation. We would like two members of the forecast team to lead each discussion; usually the SPC forecaster will manage the NAWIPS displays and lead the discussion about the experimental forecast process, and one researcher will facilitate discussion about scientific issues related to high resolution modeling. However, all participants are encouraged to contribute to the discussion. This is an excellent forum to generate discussion on a wide range of topics related to the Spring Program, and we should make sure that we are successful in raising issues of scientific and operational importance. The team is asked to document important comments, ideas, and findings made in map discussion pertaining to convective forecast issues for later review.

The map discussion is scheduled to end promptly at 1:30 pm, in order for team members to have sufficient time to conduct important model verification activities during the remainder of the afternoon.

## X. Forecaster/Participant Duties and Responsibilities

All new participants will participate in an orientation session on the morning of their first scheduled shift. However, to become familiar with program goals and objectives, all participants are asked to read the operations plan prior to their first day in the SSA.

The forecast team will be made up of four members on all days, with shorter-term visitors present on many of the days (see schedule, **Attachment A**). <u>**There are two critical tasks that must be achieved.**</u>

1) The preliminary and final forecasts, including generation of graphical and text products, should be created and issued in a timely manner, because this helps simulate a real-world forecasting environment where time deadlines must be met.

2) The subjective evaluation and verification of the model predictions will require a diligent and conscientious effort by all team members, because these findings will play a role in both future model development activities, and the application of model output by operational forecasters. It is very important that we maintain our focus on this afternoon task, and strive to form consensus opinions in the evaluation process.

Participants in the Spring Program are responsible for the following activities while on shift:

- ✔ **Complete Verification and Evaluation forms for the model forecasts and experimental severe weather forecasts valid the previous day.**

- ✔ **Complete experimental forecasts by 11 am and 12:30 pm.**

- ✔ **Set up and facilitate daily Map Discussion (including review of previous day forecasts and other relevant verification issues)**

The order and responsibilities for completing scheduled activities should depend on individual skills and areas of interest. Since the SPC forecaster has the most familiarity with equipment and data flow, they will be assigned as the lead of the forecast team.

While it is recommended the entire forecast team work together and interact on forecast issuance and evaluation activities, it is most feasible to work in groups of two on specific tasks, with interaction as needed. A suggested breakout of specific duties is as follows:

**Team Member A** - SPC Representative who should lead the forecast team during daily operations. They are responsible for facilitating the forecast process and discussion, creating forecast graphics, and writing the outlook discussions. This forecaster's primary work area will be the Linux NAWIPS workstation in the northwest corner of the SSA. Forecaster A should lead map discussion on the first day of operations, but that responsibility should be shared among other participants as they become more familiar with systems/displays later in the week.

**Team Member B** - NSSL Representative who is primarily responsible for providing insight into the performance of specific models, adding insight to the forecast process via use of model output, and providing assistance in completing the model confidence/utility evaluation forms (with Member D) during the time each forecast text discussion is being written by the SPC forecaster. This member is also responsible for documenting important discussion topics during map discussion. Their primary work area will be the Linux NAWIPS workstation located in the southeast corner of the SSA.

**Team Member C** - Visiting Scientists should provide insight into that part of the forecast process with which they are most familiar. Those with some background or interest in operational forecasting will work more closely with the SPC forecaster and assist in the outlook process. These participants should focus on their areas of expertise as it pertains to issuance of the forecast product, evaluation activities, or model development and concepts. Their primary work area will be the Linux/Windows PC and NAWIPS workstation located on the north part of the SSA. This person will work with Member B to complete model confidence/utility evaluation forms while each forecast text discussion is being written by the SPC forecaster.

**Team Member D** - This visiting scientist or forecaster will work most closely with the NSSL scientist to interpret model systems and output. They will provide perspective from the operational forecasting or research community to identify issues related to model strengths/weaknesses, and/or ways to make model output more useful to forecasters. Their primary work area will be the Linux/Windows PC and NAWIPS workstation on the south side of the SSA.

**Visitor(s)** - These visiting scientists or forecasters are invited to participate in the forecast discussion and provide insight as applicable. They are encouraged to help in the analysis of model output and work with the forecast team as applicable. Although they do not have specific responsibilities, they can contribute to the activities as their time and interests permit.

## XI. Experimental Displays and Model Data

In order to incorporate new analysis displays and NWP model data into the forecast process, several non-operational data sets will be available for use during the Spring Program. It is hoped that through a proof-of-concept methodology data sets and analysis tools which provide useful information during the Spring Program will be rapidly integrated into SPC operational data flow and workstations. *(To display the WRF models and full resolution output from the RUC and Eta models, a special Spring Program 2004 NMAP2 version is required. In an xterm window, type **sp2004** to bring up the special NMAP2 window.)*

Model data which will be available to forecasters participating in the Spring Program includes the following (model run resolution / model display grid):

12km/80km Operational Eta Model (12, 18, 00, 06z)
12km/40km Operational Eta Model (12, 18, 00, 06z)
*12km/12km Operational Eta Model (12, 00z)*
20km/40km Operational RUC Model (Hourly)
*20km/20km Operational RUC Model (12z)*
48km/40km EMC SREF-EtaKF Control Run (09, 21z)
48km/40km EMC SREF (Eta/RSM/EtaKF) (09, 21z)
*8 km/8 km EMC WRF-NMM (12z - central U.S. domain)*
*10 km/10 km EMC WRF-EM (12z – central U.S. domain)*
*4 km/4 km CAPS WRF (00z, 12z)*
*4 km/4 km NCAR WRF (00z)*
*4 km/4 km EMC WRF-NMM (00z)*

**** Italicized fields are experimental data not typically available to SPC forecasters ****
*** All model data will be available via NAWIPS workstations or Internet ***

## XI. Operations Center Hardware and Software

Spring Program forecast and evaluation exercises will take place in the Science Support Area (SSA), immediately adjacent to SPC operational forecast area. Equipment available to spring program participants includes:

1. Dual monitor Linux Workstations running NAWIPS with Netscape available for Internet access
2. Single monitor PCs with Windows XP applications (Internet, e-mail, etc.)
3. Automated Report Logging System (ARLS) for real time visual and audible alerts of any convective watches or warnings (or issuance of SPC operational products).
4. Raised monitors (including 42 inch plasma screen) to show images for map discussion.

5. National Lightning Data Network display (for CG lightning info)
6. Two laser printers for color and b/w hard copy output.

# XII. Data Archive

The following special Spring Program data will be archived on tape for post-analysis research only when specified each day at the end of the afternoon model verification activities. *If the team does not explicitly answer "yes" to the data archive question on the afternoon web page verification form, the **data will not** be archived.*

**Gridded Model Data From the Following Models:**

12km/12km Operational Eta Model (12, 00z; hourly grids through 36 hrs)
20km/20km Operational RUC Model (12z; 0, 1, 2, 3, 6, 9, 12 hrs)
48km/40km EMC SREF (Eta/RSM/EtaKF) (09z; 3 hourly through 27 hrs)
8 km/8 km EMC WRF-NMM (12z - central U.S. domain; 3 hourly through 24 hrs)
10 km/10 km EMC WRF-EM (12z – central U.S. domain; 3 hourly through 24 hrs)
4 km/4 km CAPS WRF (00z, 12z; hourly through 30 and 18 hrs, respectively)
4 km/4 km NCAR WRF (00z; hourly through 36 hrs)
4 km/4 km EMC WRF-NMM (00z; hourly through 30 hrs)

**Model GEMPAK files include**:

2m and 30 mb layer temperature, dew point
10m and 30 mb layer wind
6 km AGL wind
PMSL
CAPE and CIN using surface, 90mb mean layer, and most unstable parcels
0-1 km and 0-3 km storm-relative helicity
700 mb and 500 mb vertical velocity
3hr- and 1hr-accumulated precipitation, precipitation rate, equivalent reflectivity

**These special data are in addition to the standard hourly data archived daily at SPC**:

sfc obs, raobs, profiler
sfcOA, ruc2a
GOES-8 IR/VIS/WV
GOES-10 WCONUS IR/VIS/WV
GOES-12 ECONUS IR/VIS/WV
firewx, spc, and watch_warn text products

## XIII. Acknowledgments

Special thanks and appreciation is extended to all participants and staff for assisting in Spring Program preparations/planning, programming and data flow issues. Without the combined efforts of many SPC and NSSL staff, the Spring Program could not be conducted. In particular, special thanks to Phillip Bothwell (SPC) for providing access to radar and severe storm report verification data; Gregg Grosshans (SPC) for establishing model data flow and configuring the experimental forecasts for transmission and archival, and for developing and organizing model display files, and Jay Liang (SPC) and Doug Rhue (SPC) for assistance in configuring hardware/software in the Science Support Area. Linda Crank (SPC), Peggy Stogsdill (SPC), Sandra Allen (NSSL), and Tracy Reinke (CIMMS) ably assisted with logistical and budget support activities. We especially acknowledge the outstanding efforts and expertise of Kelvin Droegemeier, Dan Weber, and Kevin Thomas for developing and contributing the CAPS 4 km WRF runs, Morris Weisman, Chris Davis, and Wei Wang for providing the NCAR WRF runs, Zavisa Janjic, Tom Black, Matt Pyle, and Geoff DiMego for developing and contributing the EMC WRF runs. We further wish to recognize the full support of SPC and NSSL management and enthusiasm by participants from the Environmental Modeling Center (NCEP/EMC), Hydrometeorological Prediction Center (NCEP/HPC); National Weather Service Central Region Headquarters and Forecast Offices at Norman, OK and White Lake, MI; Forecast Systems Laboratory, NASA-Marshall Space Flight Center, University of Oklahoma-CIMMS, Iowa State University, University of Arizona, University of Wisconsin-Madison, University of Wisconsin-Milwaukee, University of Colorado-CIRES, University of Missouri-Columbia, Pennsylvania State University, University of Utah, Naval Postgraduate School, University at Albany-SUNY, Meteorological Service of Canada (Toronto, Montreal, and Winnipeg), and the COMET program for funding assistance for visiting faculty, who provided assistance and motivation for making such an undertaking a positive experience for everyone.

# Attachment A

Spring Program 2004 Participant Schedule (4/9/04)

**OPERATIONS SCHEDULE FOR SPC/NSSL SPRING PROGRAM 2004**
**12 APRIL - 4 JUNE 2003**

ALL SHIFTS MON-FRI WILL BE FROM 8AM-4PM. FRI OPERATIONS WILL CONCLUDE AFTER MAP DISCUSSION AT 1:30 PM, ALTHOUGH VISITING SCIENTIST SEMINARS MAY BE PRESENTED AFTER FRIDAY MAP DISCUSSION. SCHEDULES MAY BE CHANGED OR TRADED THROUGH INDIVIDUAL AGREEMENT **AND** COORDINATION WITH STEVEN WEISS (x705) OR JACK KAIN (x776).

*New Participants in the experiment are strongly encouraged to read the Operations Plan prior to working their first shift. A list of all participants by affiliation is provided at the end of this document.*

**Updates to this document are available at:**
**http://www.spc.noaa.gov/exper/Spring_2004/**

(#) - Visiting Scientist
(*) - Initial spin-up week

| **MON*** <br> **4/12** | **TUE*** <br> **4/13** | **WED*** <br> **4/14** | **THU*** <br> **4/15** | **FRI*** <br> **4/16** |
|---|---|---|---|---|
| Weiss | Weiss | Weiss | Weiss | Weiss |
| Bright | Bright | Bright | Bright | Bright |
| Levit | Levit | Levit | Levit | Levit |
| Kain | Kain | Kain | Kain | Kain |
| Carbin | Carbin | Carbin | Carbin | Carbin |

| **MON** <br> **4/19** | **TUE** <br> **4/20** | **WED** <br> **4/21** | **THU** <br> **4/22** | **FRI** <br> **4/23** |
|---|---|---|---|---|
| Mead | Mead | Mead | Mead | Mead |
| Levit | Levit | Levit | Levit | Levit |
| Baldwin | Baldwin | Baldwin | Baldwin | Baldwin |
| Kain | Kain | Kain | Kain | Kain |
| | Woodley# | | | |

| **MON** <br> **4/26** | **TUE** <br> **4/27** | **WED** <br> **4/28** | **THU** <br> **4/29** | **FRI** <br> **4/30** |
|---|---|---|---|---|
| Peters | Peters | Peters | Peters | Peters |
| Janish | Janish | Janish | Janish | Janish |
| Burgess | Burgess | Burgess | Burgess | Burgess |
| Homar | Homar | Homar | Homar | Homar |
| | | Du# | Du# | Du# |
| | | | Mullen# | Mullen# |

| **MON** <br> **5/3** | **TUE** <br> **5/4** | **WED** <br> **5/5** | **THU** <br> **5/6** | **FRI** <br> **5/7** |
|---|---|---|---|---|
| Edwards | Edwards | Edwards | Edwards | Edwards |
| Schultz | Schultz | Schultz | Schultz | Schultz |
| Roebber | Roebber | Roebber | Roebber | Roebber |
| Erfani | Erfani | Erfani | Erfani | Erfani |
| | King# | King# | King# | King# |
| | | Uccellini# | | |

| MON | TUE | WED | THU | FRI |
|---|---|---|---|---|
| **5/10** | **5/11** | **5/12** | **5/13** | **5/14** |
| Racy | Racy | Racy | Racy | Racy |
| Spencer | Spencer | Spencer | Spencer | Spencer |
| Manikin | Manikin | Manikin | Manikin | Manikin |
| Mann | Mann | Mann | Mann | Mann |
| Steenburgh# | Steenburgh# | Steenburgh# | | |
| Markowski# (days TBD) | Manousos# | Manousos# | Manousos# | |

| MON | TUE | WED | THU | FRI |
|---|---|---|---|---|
| **5/17** | **5/18** | **5/19** | **5/20** | **5/21** |
| Goss | Goss | Goss | Goss | Goss |
| Wandishin | Wandishin | Wandishin | Wandishin | Wandishn |
| Tripoli | Tripoli | Tripoli | Tripoli | Tripoli |
| Market | Market | Market | Market | Market |
| | Bosart# | Bosart# | Bosart# | Bosart# |
| Weisman# | Weisman# | Weisman# | Weisman# | Weisman# |
| Richardson# | Richardson# | | | |
| Janjic# (days TBD) | Wasula# (days TBD) | | | |
| | Galarneau# (days TBD) | | | |

| MON | TUE | WED | THU | FRI |
|---|---|---|---|---|
| **5/24** | **5/25** | **5/26** | **5/27** | **5/29** |
| Dial | Dial | Dial | Dial | Dial |
| Lapenta | Lapenta | Lapenta | Lapenta | Lapenta |
| Gallus | Gallus | Gallus | Gallus | Gallus |
| Patrick | Patrick | Patrick | Patrick | Patrick |
| Toth# (days TBD) | | | | |

| MON | TUE | WED | THU | FRI |
|---|---|---|---|---|
| **5/31** | **6/1** | **6/2** | **6/3** | **6/4** |
| Weiss | Weiss | Weiss | Weiss | Weiss |
| Gourley | Gourley | Gourley | Gourley | Gourley |
| Mapes | Mapes | Mapes | Mapes | Mapes |
| J Brown | J Brown | J Brown | J Brown | J Brown |
| Bukovsky# | Bukovsky# | Bukovsky# | Bukovsky# | Bukovsky |
| | Elsberry# | Elsberry# | Elsberry# | Elsberry |

## Full-Time Participating Scientists and Forecasters

**SPC**: S. Weiss, J. Levit, R. Edwards, G. Dial, G. Carbin, C. Mead, S. Goss, J. Peters, J. Racy
**NSSL**: J. Kain, M. Wandishin, P. Spencer, M. Baldwin, D. Burgess, V. Homar, D. Schultz, J. Gourley
**NCEP/EMC**: G. Manikin
**NWS/OUN**:
**NWS/DTX**: G. Mann
**Forecast Systems Laboratory:** J. Brown (Tentative)
**NASA-MSFC:** W. Lapenta
**University of Oklahoma**: M. Bukovsky
**University of Wisconsin - Madison:** G. Tripoli
**University of Wisconsin – Milwaukee:** P. Roebber
**University of Missouri – Columbia:** P. Market
**Iowa State University**: B. Gallus
**University of Colorado:** B. Mapes
**Koch/Entergy Corp**: P. Janish
**Met. Service of Canada**: A. Erfani, D. Patrick

## Part-Time Scientists and Forecasters

**NCEP:** L. Uccellini
**NCEP/EMC:** B. Ferrier, J. Du, Z. Janjic, Z. Toth
**NCEP/HPC:** P. Manousos
**Met. Service of Canada**: P. King, R. Kuhn
**COMET**:
**NSSL**: M. Coniglio, H. Brooks
**NWS/OUN**: M. Foster, K. James
**SPC:** R. Schneider, J. Schaefer, D. Bright
**Forecast Systems Laboratory**:
**Naval Postgraduate School:** R. Elsberry
**NCAR:** M. Weisman
**University of Arizona:** S. Mullen
**University at Albany – SUNY:** L. Bosart, A. Wasula, T. Galarneau
**Pennsylvania State University:** Y. Richardson, P. Markowski
**Valparaiso University:** A. French
**Finish Meteorological Institute:** J. Teittinen
**Woodley Weather Consultants:** W. Woodley

# Attachment B

Experimental Severe Weather Forecast Product Instructions

# Experimental Severe Weather Forecast Product Instructions Spring Program 2004

Experimental 6-hour severe weather forecasts for the 18-00z period will be issued twice daily Monday-Friday. (On a small number of occasions when initial convective development is expected to be delayed until near or shortly after 00z, the valid period can be adjusted to 21-03z or even 00-06z.) These forecasts will be very similar to the operational SPC outlooks, except only total severe storm probability contours will be formulated (no categorical outlook, and no general thunderstorms will be forecast). The same probability contours used in the operational outlooks will be used (5, 15, 25, 35, and 45 %), along with a probability of significant severe storms when appropriate. The Preliminary Forecast is issued by 11 am CDT, and forecasters will utilize traditional forecasting methods based on observational data and output from the 12z Eta and RUC models and 09z SREF. Forecasters will look at Eta12 and RUC20 fields of precipitation (accumulated over 3-hr and 1-hr periods), precipitation rate, and equivalent reflectivity at full model resolution, in addition to the typical SPC displays of Eta40 and RUC fields displayed on a 40 km grid. Once the Preliminary Forecast and associated model confidence/utility forms have been completed, a Final Forecast will be issued by 12:30 pm CDT based on additional information received from the 00z NCAR WRF, 00z CAPS WRF, and 00z EMC WRF-NMM. The goal is to explore the utility of near-stormscale model guidance in severe weather forecasting, and to determine if it provides value-added information over and above that provided by traditional deterministic and SREF models, especially relating to aspects of convective initiation, evolution, and mode.

For the **Preliminary Severe Weather Forecast**, the forecaster will draw/save probability contours in NMAP2, and save the forecast in the same manner as for operational outlooks. The time period will default to 1800 to 0000z. If your forecast period is 2100-0300z or 0000-0600z you will need to manually change the valid time. **After saving the outlook, enter the command: sp04bg STN prelim # in an xterm window (STN is the METAR centerpoint site ID and # is NAWIPS workstation number).** This is necessary to archive the outlook, attach a date/time to the graphics file corresponding to the preliminary outlook date/time, and send the graphics to the web page.

Next, on the preliminary forecast web page (below the forecast graphic), the forecaster will complete the following three sections: 1) whether thunderstorms and severe thunderstorms are ongoing within or immediately upstream from the forecast area at the issuance time, 2) the predicted time of the first severe storm report, and 3) a series of probability values corresponding to the likelihood of three basic convective modes (isolated cells, multicellular cluster(s), and quasi-linear convective systems (QLCS) or squall lines) forming during the forecast period. (See Attachment F for information about convective modes.) Finally, a discussion will be written in a text box on the web page that is similar to operational discussions, except a prime emphasis should be on the use and perceived value of the model guidance in preparing the forecast. We are most interested in the ability of the models to provide information on the details of “where and where” convection will initially develop, the intensity and evolution of the convective system(s), and the structure or mode(s) of the convection, including possible mode changes during the period, and inherent uncertainty in the convective forecast process. These topics should be explicitly discussed in the text box below the convective mode entries on the web page.

For the **Final Severe Weather Forecast**, the forecast team will assess output from the 00z high resolution WRF forecasts from EMC, CAPS, and NCAR and determine if any of the near-stormscale guidance provides new and useful forecast information about details of convective initiation, evolution, and mode. After examining the WRF output the team should decide if their initial assessment of severe potential has changed. If forecaster confidence is increased (decreased) concerning location, timing, evolution or mode that might make severe weather more (less) likely then the forecast team might consider having higher (lower) probability values compared to the preliminary outlook. The preliminary forecast should serve as the "first guess" for the final forecast, with adjustments (if any) based on information from the 00z WRF models.

After the final forecast probability contours are completed, the outlook is saved following the same procedures used for the preliminary forecast. (Remember to enter the **sp04bg STN final** # command after saving the forecast.) Once the updated forecast is available on the Final Forecast web page, enter updated information about ongoing thunderstorm and severe thunderstorm activity, the predicted time of the first severe report, and a second set of mode probabilities. Finally, a second discussion is written that documents the influence of the WRF output in assessing details of convective initiation, evolution, mode, and the resultant the severe weather threat.

# Attachment C

Real-Time Model Evaluation
During Preparation of Severe Weather Forecasts
(Web Based Forms)

# Real-Time Model Evaluation During Preparation of Severe Weather Forecasts Spring Program 2004

## I. Real-Time Model Evaluation During Preliminary Forecast: Mesoscale Models/SREF Guidance

In the online preliminary severe weather forecast evaluation web page, the following questions are asked once the forecast graphic is transferred from NAWIPS to the web page:

A. Categorize the type of thunderstorms ongoing or immediately upstream from the forecast area at issuance time:
    No thunderstorms xxx
    Non-severe thunderstorms xxx
    Severe thunderstorms xxx

Where xxx denotes approximate percent of time/space during the forecast period affected by each mode. The sum of these three percentages should total 100%.

B. What is the predicted time of the first severe weather report in the forecast area: 18-20z, 20-22z, 22-00z, after 00z

C. Probability of isolated cells during the forecast period: xxx
    Probability of multicells during the forecast period: xxx
    Probability of quasi-linear convective systems during the forecast period: xxx
    (Note: these forecast probability values are mutually exclusive)

D. A blank text box allowing for a written discussion focusing on the synoptic/mesoscale setup and the use of mesoscale model output in the decision-making process.

E. Model Evaluation

Models used during the preparation of the experimental forecasts will be evaluated in real time as part of the forecast assessment process. This allows us to gain a sense of forecaster confidence in the specific model solutions.

**Instructions:** For each of the models listed below, express your confidence in model forecasts of 1) convective initiation, 2) convective evolution, and 3) convective mode. All assessments should be based on model precipitation forecasts, using the highest temporal resolution data available for a given model. For example, equivalent reflectivity or instantaneous rainfall rate would be a better choice than 3 h rainfall. Model vertical velocity fields (700-500 mb UVV) may also be overlaid to infer instantaneous precipitation tendencies or additional information about convective mode.

Please refer to the scale below in completing your subjective evaluation:

| <u>**0**</u> | <u>**5**</u> | <u>**10**</u> |
|---|---|---|
| **No Confidence** | **Moderate Confidence** | **Highest Confidence** |

**No Confidence**: Forecast team completely rejects model precipitation forecast as an accurate indicator of convective weather.

**Moderate Confidence**: Forecast team has a moderate amount of confidence that model precipitation forecast is an accurate indicator of convective weather.

**Highest Confidence:** Forecast team has complete confidence that model precipitation forecast is an accurate indicator of convective weather.

Note: we are not trying to forecast *quantitative* precipitation amounts per se. Rather, we are trying to determine the usefulness of the model precipitation forecast to a severe weather forecaster concerned with convective initiation, evolution, and mode.

Make sure that subjective numerical ratings are consistent in a relative sense. For example, if you have significantly more confidence in the precipitation forecast from model A compared to model B, make sure that model A has a higher rating than model B.

**<u>I. Convective Initiation</u>:** *How confident are you that initiation of precipitation in the model forecast will correspond well to the timing of observed convective initiation within the evaluation domain?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

**<u>II. Convective Evolution</u>:** *How confident are you that the model precipitation forecast will correspond well to the mesoscale evolution of convection within the evaluation domain, including direction and speed of system movement, areal coverage, configuration and orientation of mesoscale features?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

**<u>III. Model Forecast Convective Mode Identification</u>:** *If you were to make a literal interpretation of model precipitation/reflectivity fields within the experimental severe weather forecast area, what convective modes would the following models predicted?*
(**Note:** the sum of the three mode probabilities should total 100%)

**12z 12 km Eta:** Percent of isolated cells xxx
Percent of multicell clusters xxx
Percent of linear systems xxx (the sum of these three percentages should total 100%)

**12z 20 km RUC:** Percent of isolated cells xxx
Percent of multicell clusters xxx
Percent of linear systems xxx (the sum of these three percentages should total 100%)

Comments:

**III. Convective Mode Confidence**: *How confident are you that the model precipitation/UVV forecast will correspond well to the convective mode indicated by instantaneous base-reflectivity radar data, focusing on basic modes of 1) isolated strong/intense cells, 2) linear structure, and 3) multicellular clusters?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

## B. SREF Output

*How do you rate the value of SREF guidance in helping to quantify uncertainty in today's severe weather forecast?*

| | No Value | | | | | Some Value | | | | | Great Value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

*How do you rate the value of postage stamp output that displays all 15 SREF members and the latest Eta forecast to illustrate the range of today's forecast possibilities?*

| | No Value | | | | | Some Value | | | | | Great Value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| O | O | O | O | O | O | O | O | O | O | O | O |

| |
|---|
| Comments: |

## II. Real-Time Model Evaluation During Final Forecast: 4km WRF/NMM Guidance

In the online preliminary severe weather forecast evaluation web page, the following questions are asked once the forecast graphic is transferred from NAWIPS to the web page:

A. Categorize the type of thunderstorms ongoing or immediately upstream from the forecast area at issuance time:
No thunderstorms O
Non-severe thunderstorms O
Severe thunderstorms O

B. What is the predicted time of the first severe weather report in the forecast area: 18-20z, 20-22z, 22-00z, after 00z

C. Probability of isolated cells during the forecast period: xxx
Probability of multicells during the forecast period: xxx
Probability of quasi-linear convective systems during the forecast period: xxx
(Note: these forecast probability values are mutually exclusive)

D. A blank text box allowing for a written discussion focusing on the synoptic/mesoscale setup and the use of mesoscale model output in the decision-making process.

E. Model Evaluation

Models used during the preparation of the experimental forecasts will be evaluated in real time as part of the forecast assessment process. This allows us to gain a sense of forecaster confidence in the specific model solutions.

**Instructions:** For each of the models listed below, express your confidence in model forecasts of 1) convective initiation, 2) convective evolution, and 3) convective mode. All assessments should be based on model precipitation forecasts, using the highest temporal resolution data available for a given model. For example, equivalent reflectivity or instantaneous rainfall rate would be a better choice than 3 h rainfall. Model vertical velocity fields (700-500 mb UVV) may also be overlaid to infer instantaneous precipitation tendencies or additional information about convective mode.

Please refer to the scale below in completing your subjective evaluation:

| 0 | 5 | 10 |
|---|---|---|
| **No Confidence** | **Moderate Confidence** | **Highest Confidence** |

**No Confidence**: Forecast team completely rejects model precipitation forecast as an accurate indicator of convective weather.

**Moderate Confidence**: Forecast team has a moderate amount of confidence that model precipitation forecast is an accurate indicator of convective weather.

**Highest Confidence**: Forecast team has complete confidence that model precipitation forecast is an accurate indicator of convective weather.

Note: we are not trying to forecast *quantitative* precipitation amounts per se. Rather, we are trying to determine the usefulness of the model precipitation forecast to a severe weather forecaster concerned with convective initiation, evolution, and mode.

Make sure that subjective numerical ratings are consistent in a relative sense. For example, if you have significantly more confidence in the precipitation forecast from model A compared to model B, make sure that model A has a higher rating than model B.

**I. Convective Initiation:** *How confident are you that initiation of precipitation in the model forecast will correspond well to the timing of observed convective initiation within the evaluation domain?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

**II. Convective Evolution**: *How confident are you that the model precipitation forecast will correspond well to the mesoscale evolution of convection within the evaluation domain, including direction and speed of system movement, areal coverage, configuration and orientation of mesoscale features?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

**III. Model Forecast Convective Mode Identification:** *If you were to make a literal interpretation of model precipitation/reflectivity fields within the experimental severe weather forecast area, what convective modes would the following models predicted?*
(**Note:** the sum of the three mode probabilities should total 100%)

**00z 4 km WRF-CAPS:** Probability of isolated cells xxx
Probability of multicell clusters xxx
Probability of linear systems xxx

Comments:

**00z 4 km WRF-NCAR**: Probability of isolated cells xxx
Probability of multicell clusters xxx
Probability of linear systems xxx

Comments:

**00z 4 km WRF/NMM-EMC**: Probability of isolated cells xxx
Probability of multicell clusters xxx
Probability of linear systems xxx

Comments:

**III. Convective Mode Confidence**: *How confident are you that the model precipitation/UVV forecast will correspond well to the convective mode indicated by instantaneous base-reflectivity radar data, focusing on basic modes of 1) isolated strong/intense cells, 2) linear structure, and 3) multicellular clusters?*

| | **NA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

# Attachment D

Spring Program 2004
Identification of Convective Mode and
Subjective Verification of Severe Weather Forecast Accuracy
(Web Based Forms)

# Convective Mode Identification and Severe Weather Forecast Subjective Verification Form Spring Program 2004

## I. Convective Mode Identification

Using base reflectivity radar data, examine the 6 hour radar loop during the forecast valid period and identify the primary convective mode(s) that occurred. See Attachment F for guidance on convective modes.

**What was the Percentage of Observed Convective Mode(s) Occurred During the Forecast Period?**
Isolated Cells xxx Multicell Clusters xxx Convective Lines xxx
(The sum of these three percentage values should total 100%)

**The Most Significant Severe Reports Were Associated with Which Mode(s)?**
Isolated Cells O Multicell Clusters O Convective Lines O

| Comments about Observed Convective Mode: |
|---|
| |

## II. Subjective Verification of Preliminary Severe Weather Forecast:

**Overall Rating of Preliminary Severe Thunderstorm Forecast**

In NMAP2 window 1 overlay the preliminary forecast with the vgf file of severe reports for the 6 hour valid period. Rate the accuracy of the forecast on a scale from 0-10, with 0 being a very poor forecast, and 10 being a nearly perfect forecast. Since the forecast covers a regional domain, some forecast regions may be more accurate than others - formulate an overall rating by averaging the accuracy of different forecast areas when necessary. Areas with greater severe storm occurrence or higher forecast probabilities should be given more weight in the rating process.

If the preliminary forecast was not available, **click on the checkbox labeled "NA".**

**Preliminary Severe Thunderstorm Forecast Rating:**

| **NA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| O | O | O | O | O | O | O | O | O | O | O | O |

Add additional comments related to reasons for your rating - e.g., regions where the forecast was good, and where it was not. Include aspects of predicted and observed coverage, and any displacement errors that were factors in your rating, e.g., the primary axis of severe weather was east of the forecast location.)

| Comments: |
|---|
| |

# III. Subjective Verification of Final Severe Weather Forecast:

**Overall Rating of Final Severe Thunderstorm Forecast**

In NMAP2 window 2 overlay the final forecast with the same vgf file of severe reports for the 6 hour valid period. Rate the accuracy of the forecast on a scale from 0-10, with 0 being an extremely poor forecast, and 10 being a nearly perfect forecast. ***Pay close attention to the accuracy of this forecast compared to the preliminary forecast.*** If the final forecast was different from the preliminary forecast, determine if the changes resulted in a better forecast, worse forecast, or no change in perceived accuracy/usefulness to the product user. Make sure your rating reflects this relative comparison - for example, if the final forecast improved the preliminary forecast, the final forecast rating should be higher than the preliminary forecast rating.

If the final forecast was not available, **click on the checkbox labeled "NA".**

**Final Severe Thunderstorm Forecast Rating:**

| **NA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| O | O | O | O | O | O | O | O | O | O | O | O |

Add additional comments related to reasons for your rating - be sure to consider the rating of the final forecast relative to the preliminary forecast. If the final forecast showed changes from the preliminary forecast, discuss the relative impact of the changes on forecast accuracy (e.g., did the changes help or hurt the forecast?)

| Comments: |
|---|
| |

# Attachment E

Spring Program 2004
Deterministic Model Precipitation Subjective Evaluation Forms
(Web Based Forms)

## II. Next-Day Model Verification Instructions: All Models

For each of the models listed below, provide a subjective assessment of the correspondence between observations and model forecasts of 1) convective initiation, 2) convective evolution, and 3) convective mode. All assessments should be based on model precipitation forecasts, using the highest temporal resolution data available for a given model and comparing with similarly timed radar data. For example, if the highest frequency output from the Eta is 3-h rainfall, compare with 3-hourly radar composites; compare equivalent reflectivity from high resolution models with normal (instantaneous) base-reflectivity fields. Model vertical velocity fields (700-500 mb UVV) may also be overlaid to infer characteristics of convective mode.

Please refer to the scale below in completing your subjective evaluation:

| 0 | 5 | 10 |
|---|---|---|
| **No Correspondence** | **Moderate Correspondence** | **Excellent Correspondence** |

**No Correspondence**: Model missed primary features and would have provided misleading guidance to a severe weather forecaster.

**Moderate Correspondence**: Model captured some primary features and would have provided some useful guidance to a severe weather forecaster.

**Excellent Correspondence**: Model captured all important features, and would have provided excellent guidance to a severe weather forecaster.

Note: we are not verifying *quantitative* precipitation amounts per se. Rather, we are trying to determine the usefulness of the model precipitation forecast to a severe weather forecaster concerned with convective initiation, evolution, and mode.

Make sure that subjective numerical ratings are consistent in a relative sense. For example, if you believe that model A provided significantly more accurate and useful guidance than model B, make sure that model A has a higher rating than model B.

### **I. Convective Initiation**: *How well did the model precipitation forecast correspond to the timing of convective initiation within the evaluation domain?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 8km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 10km WRF/EM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

**IV. Question:** *How would you characterize the relevant convective initiation?*

O Continuation of ongoing organized convection within evaluation domain
O Movement of ongoing organized convection into evaluation domain
O New convective development, not associated with ongoing local convection
O Other (please explain below)

| Comments: |
|---|

**V. Convective Evolution**: *How well did the model precipitation forecast correspond to the mesoscale evolution of convection within the evaluation domain, including direction and speed of system movement, areal coverage, configuration and orientation of mesoscale features?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 8km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 10km WRF/EM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

| Comments: |
|---|

**VI. Convective Mode**: *How well did the model precipitation forecast/UVV field correspond to the convective mode indicated by instantaneous base-reflectivity radar data, focusing on basic modes of 1) isolated strong/intense cells, 2) linear structure, and 3) multicellular clusters?*

| | NA | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **00Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF-NCAR** | O | O | O | O | O | O | O | O | O | O | O | O |
| **00Z 4km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 4km WRF-CAPS** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 8km WRF/NMM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 10km WRF/EM-EMC** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 12km Eta** | O | O | O | O | O | O | O | O | O | O | O | O |
| **12Z 20km RUC** | O | O | O | O | O | O | O | O | O | O | O | O |

Comments:

# Attachment F

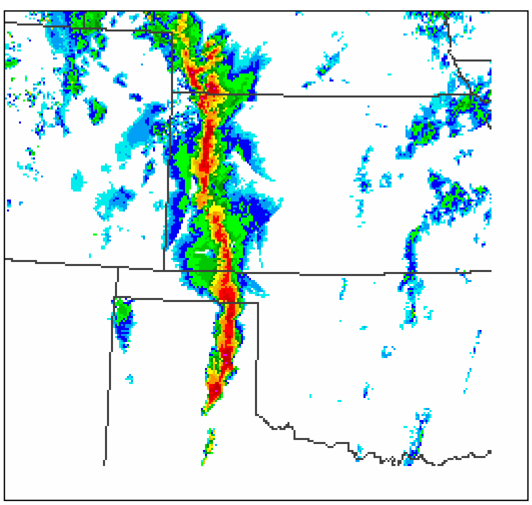
Spring Program 2004
Convective Mode Categories

# Convective Mode Categories

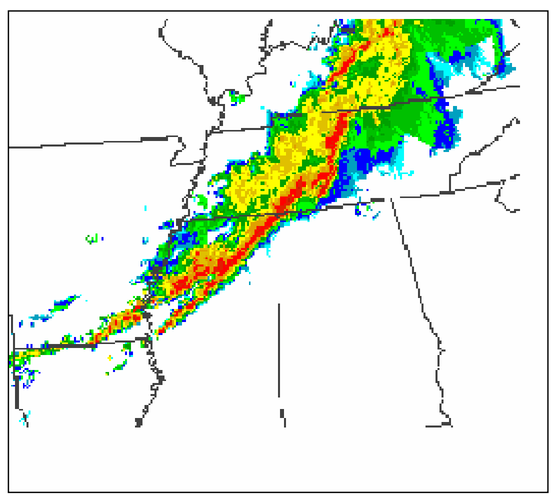
Convective mode refers to the various classification categories that have been used to characterize observed patterns of thunderstorm occurrence. Our focus will be on the mesoscale and larger stormscale structures that are observed using radar reflectivity displays. For our purposes, a convective echo is defined as having radar reflectivity greater than 40 dBZ, which eliminates weaker (non-severe) convection from the analysis. Three basic modes of hierarchy will be used: linear or convective line (commonly known as squall lines or quasi-linear convective systems QLCS), multicellular clusters (including Mesoscale Convective Systems or MCS), and isolated cells.

**1. Linear Mode:** A convective line is defined as a contiguous or nearly contiguous chain of radar echoes that share a common leading edge and move approximately in tandem. They can be arranged in nearly a straight line or a moderately curved arc. Segments of the line may occasionally display different speeds of forward movement, resulting in small scale waves or LEWPS (Line Echo Wave Pattern) within the line. Lines contain a length-to-width ratio of at least 5:1, with length dimensions of at least 100 km (54 nm), lasting for at least 60 minutes. Recent studies of squall lines have noted additional characteristics pertaining to the distribution of the stratiform precipitation region relative to the stronger reflectivity concentrated in the convective line, forming subcategories of lines with trailing stratiform, leading stratiform, and parallel stratiform. Since our primary concern is severe convective weather, we will focus on identification of the higher reflectivity linear convective structure, with lesser emphasis on the configuration of any stratiform component.

Here are two examples of linear convective mode:

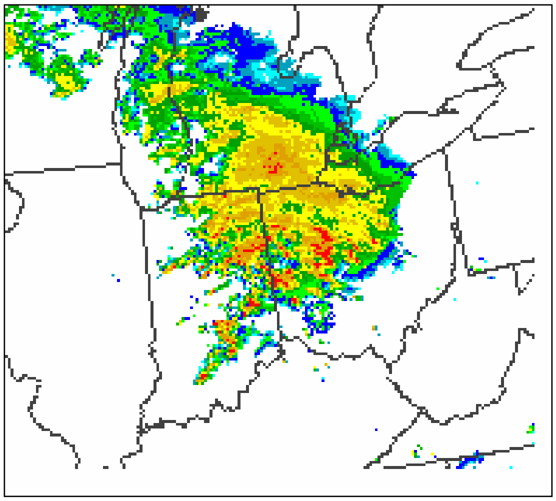


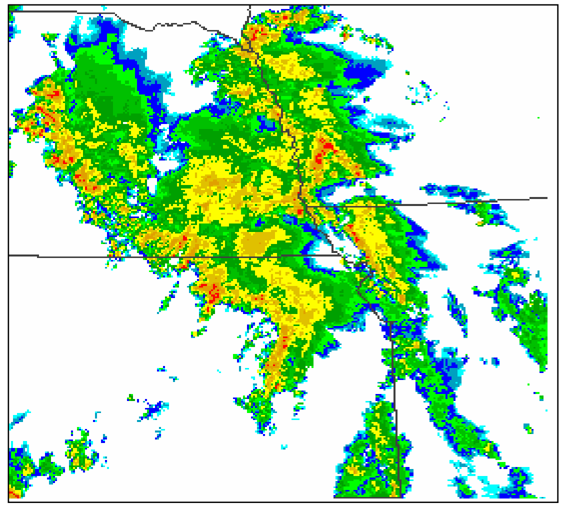
**2.**



**Multicellular Cluster Mode:** A multicellular cluster is defined as a system of convective storms (multiple updrafts) organized on the mesoscale and not displaying linear characteristics (length to width ratio of less than 5:1). A multicellular cluster may take on a semi-circular shape and typically contain regions of higher reflectivity embedded within the conglomeration of cells. It covers a minimum area of 500 $km^2$ (146 $nm^2$) and lasts 60 minutes or more, with many multicellular clusters typically have larger time/space scales.

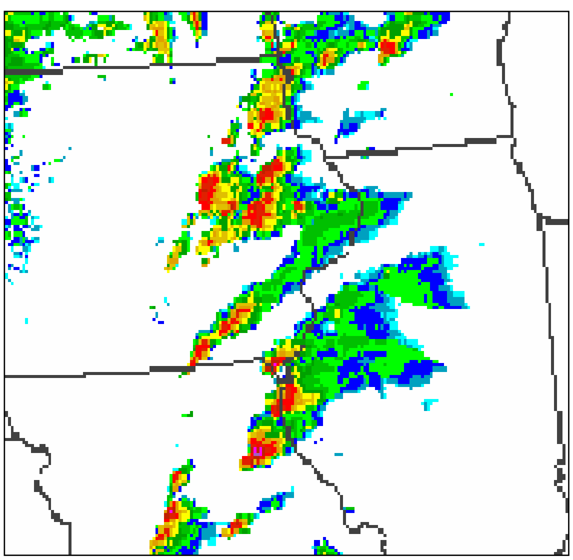
Here are two examples of Multicellular Clusters:

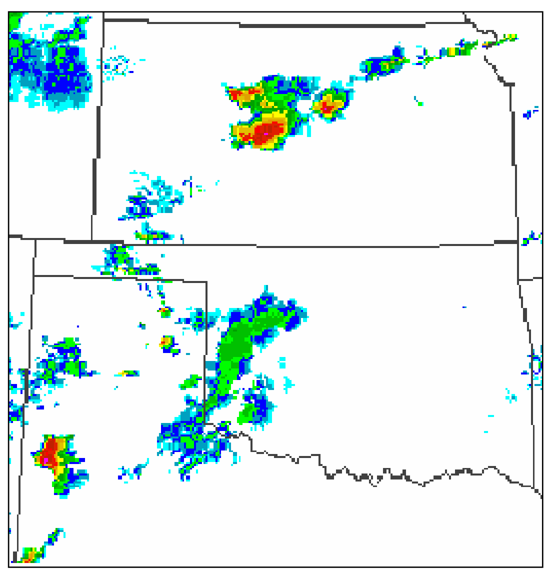




**3. Isolated Cell Mode:** Isolated cells are discrete convective updrafts with sufficient separation from adjacent convective cells to result in pronounced gaps in radar reflectivity coverage. Isolated cells have a 40 dBZ spatial extent that lasts at least 30 minutes and covers no more than 500 $km^2$ (146 $nm^2$). Isolated cells can occasionally organize into dynamically unique entities such as supercells and bow echoes which produce a disproportionate share of severe convective weather events, and can last for several hours or more. (Note that these specialized stormscale structures of supercells and bow echoes can also be embedded within mesoscale lines and clusters at times. In these cases, the mesoscale line or multicellular cluster takes precedence in the classification system.)

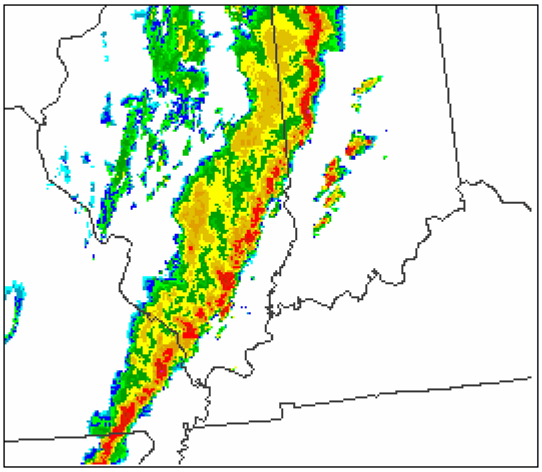
Here are two examples of isolated cell mode:





It is not uncommon for multiple modes of convection to occur simultaneously (e.g., a squall line with leading isolated cells), or for the primary mode to evolve with time (e.g., the initial development of isolated cells coalesce into a line of convection several hours later).

Example of a convective line with leading isolated cells:



In these cases it will be necessary to document the occurrence of the mixed modes of convection during the verification activities. In addition, the experimental severe weather forecasts of mode may contain multiple selections that were chosen by the forecaster, and clarification of the anticipated modes should be included in the written forecast discussion accompanying the forecast.

**Note:** radar observed storms and model generated precipitation areas will often not easily fall into neatly defined classification bins. Our interpretation of mode may reflect considerable uncertainty as observed convection or model precipitation areas can straddle the interface between isolated cells and multicellular mode, or multicellular and linear modes. In these situations, it may be helpful to consider the scale resolution limits of the WRF models we are examining (smallest grid spacing of 4 km), and the needs of operational forecasters who wish to distinguish between three basic classes of deep convection: 1) organized mesoscale convective systems (MCSs) that can be further categorized into either linear or non-linear structures, and 2) persistent deep convective elements that are often not as well organized on mesoscale time/space scales, which we will call isolated cells. It is recognized that these working definitions will not completely reflect true stormscale structures where multiple updrafts may be identified by high resolution radar within a single convective element. However, classification of deep convection into these three basic structures is expected to provide useful information to severe weather forecasters concerned with the relationship between basic convective modes and types of severe weather threat (hail, wind, and/or tornadoes) that may be most likely to occur.